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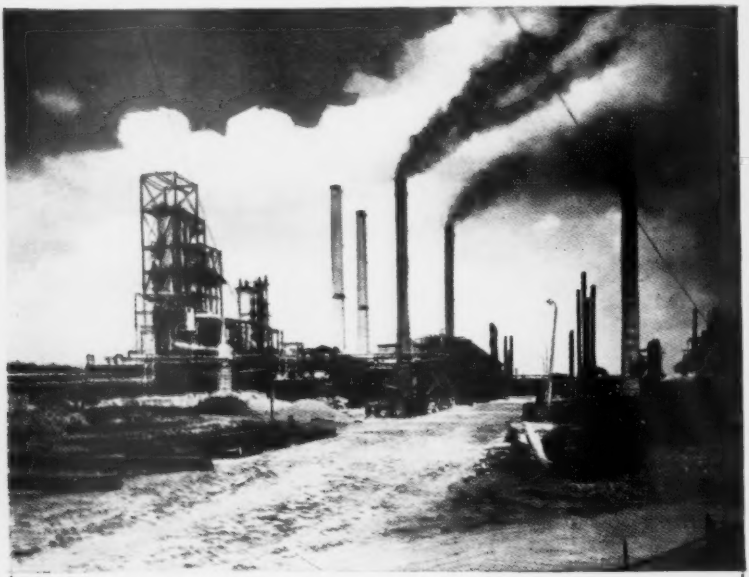

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Editor: George Sell

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OILFIELDS OF THE COMMONWEALTH *

Introduction

The Commonwealth is the world's second largest user of oil products, its consumption being exceeded by that of the U.S.A. alone; but whereas the United States is also the world's chief oil producer, the few proven oilfields within the Commonwealth are quite inadequate for its needs. Though British companies have large interests in important oil-producing countries overseas, every effort is also being made to discover fresh oilfields within the Commonwealth itself. In the following pages are surveyed the extent of indigenous oil resources already known in the Commonwealth, the prospects of developing additional resources, and also the development of oil refineries to operate on both home-produced and imported crude oil.

The world's major proven oil reserves are centred upon five main regions; North America (chiefly the U.S.A.), the Caribbean, the Middle East, the Caspian to Volga-Ural areas of Russia, Indonesia and British Borneo. In 1951 they produced altogether over 580 million tons of crude oil and natural gasoline—some 95 per cent of total world production. The main oil-producing areas of the Commonwealth are Canada, British Borneo, and Trinidad. As the following table shows, these three are the only territories within the Commonwealth producing as much as one million tons of crude oil a year.

*Memorandum compiled by Petroleum Information Bureau.

COMMONWEALTH OIL PRODUCTION
(including natural gasoline)

Country	1951*	1950	1946	1938
	Thousand metric tons			
Canada	6,500	3,900	1,000	900
British Borneo	5,000	4,200	300	900
Trinidad	3,000	3,000	3,000	2,600
India	300	300	300	400
Pakistan	200	200		
United Kingdom	45	45	56	—
Others†	—	—	—	1,100
Total	15,045	11,645	4,656	5,900

A production of some 15 million tons is totally insufficient for the Commonwealth's needs, which are about four times this amount, totalling over 60 million tons annually, including bunker oils. Great efforts are being made to increase production and to discover additional oil supplies both in the countries where oilfields are already known and in other areas of the Commonwealth, for instance in Africa, and Australia. In Western Canada alone more than 100 field exploration parties were operating in 1951 and 140 drilling rigs were in continuous operation. The importance of the known Commonwealth oilfields and the search for new sources of supply within the Commonwealth is here examined.

Canada

Today, Canada is among the world's ten leading oil-producing countries, but although her first oilfields were developed in the 1860's, Canadian output remained small for many decades and indeed until 1949 had never reached an annual total of 2,000,000 tons. The rather gradual development of her oil resources was undoubtedly influenced by the availability of abundant supplies of oil from other sources, especially the U.S.A. Her proximity to the United States also encouraged Canada to become a great user of oil and her consumption per head of population exceeds that of any other country save the U.S.A. herself.

In recent years, however, great efforts have been made to increase Canadian output—stimulated, no doubt, by the fact that the U.S.A., despite her vast production, has become a net oil importer. The discovery of a major oilfield at Leduc, near Edmonton, in 1947, greatly encouraged exploration work, and later discoveries have made it certain that Canadian production—already, in 1951, equivalent to about seven times the output of 1938—can be raised to a much higher level in the future. As yet, however, it still falls short of Canadian consumption, which is about 17,000,000 tons a year.

Alberta is the centre of Canada's oil industry, for several large oilfields have already been discovered and developed in this province. Turner Valley, lying at the foot of the Rockies, near Calgary, has an oil industry dating from 1914, when oil was first discovered, though the main producing level, at greater depth, was only found in 1936. Peak output of 1,400,000 tons was reached in 1942, but since then the level of production has steadily declined and in the summer of 1948 was surpassed by that of the Leduc-Woodbend oilfield, lying 20 miles south-west of Edmonton, the discovery of which in the previous year had aroused world-wide interest. The oil resources of this field are known to be much greater than those of Turner Valley. In September 1948, another large oilfield was discovered at Redwater, some 25 miles north-east of Edmonton. In 1950 this became Canada's leading producing field, and it has already been developed sufficiently to prove that its reserves are greater than those of any other Canadian oilfield yet discovered.

During 1949, several other oilfields were proved within a radius of 30 miles from Edmonton. Among the more important were Joseph Lake, Excelsior, Campbell, and Golden Spike; another

*Estimated.

†In 1938 Burma, with a production of 1,100,000 tons, was included in the Commonwealth, which she has now left. Owing to war damage and delay in post-war reconstruction, her oil production has virtually ceased for the time being.

Turner Valley, Canada, in winter with the Rockies in the distance.

interesting find was made at Stettler, some 80 miles south of Edmonton and thus outside the area where other discoveries had been made. Since then, oil has been found in other places, including Acheson-Stony Plain, 8 miles west of Edmonton, where a most promising oil discovery was made in 1950.

At Lloydminster, on the border of Alberta and Saskatchewan, a small oilfield has been in production since 1939, and recently it has been further developed. Unlike the principal Albertan fields, which contain a light crude oil, Lloydminster yields a very heavy crude giving a high proportion of fuel oil and asphalt. Late in 1951, it was reported that a medium-type crude oil had been discovered in another part of Saskatchewan. In the same year, the province of Manitoba, to the east of Saskatchewan, reported its first oilfield had been located at Virden, near the U.S. border.

Eastern Canada also has its oilfields, and indeed this area was responsible for the first oil production in Canada. The presence of seepage oil was noted in Ontario as long ago as 1830, and at Oil Springs, Ontario, one well which actually produced a small quantity of oil was completed within a few months of the drilling of Drake's well in Pennsylvania in 1859. Also in Ontario, the Petrolia field, discovered in 1865, is still producing, along with several other small oilfields which are almost as old. Production in Eastern Canada, now about 30,000 tons per annum, has never been large however.

In 1920 oil was discovered in the North West Territories, near Fort Norman, almost on the edge of the Arctic Circle, and this Norman Wells field was developed sufficiently to supply the needs of the local population, consisting mainly of miners and trappers whose annual oil requirements totalled a few thousand tons. During the last war this field became the basis of the Canol Project, which supplied oil by pipeline to the forces stationed in Alaska, and output at Norman Wells was expanded considerably—the number of wells was raised from seven to sixty-seven by the end of 1944, when production was at an annual rate of about 175,000 tons. But the field is too far distant from any main consuming area to make transportation of its oil an economic proposition, and since 1945, when the Canol operation was discontinued, production has been reduced back to the level of local demand. Reserves in this oilfield are sufficient, however, to allow of a much higher production rate should the need once more arise.

Although Canada's domestic oil supplies are well below the level of demand, output will be further increased during the next few years. Production in Alberta is restricted due to lack of available markets. For a long period, proven oil reserves were insufficient to justify the construction of long-distance transport facilities to distant oil-consuming areas, but lately, with the discovery of important new oilfields, pipelines and refineries have been

expanded to meet the demands of neighbouring regions, and the end of 1950 saw the completion of a 1,150 mile crude oil pipeline from Edmonton, via Regina, to Superior, Wisconsin, U.S.A., on the Great Lakes. This line has an initial capacity of about 5,000,000 tons a year to Regina, where some of the oil is refined, and of some 3,500,000 tons per annum from Regina to Superior. From Superior, the oil is transported by specially-constructed tankers; most of this oil goes to Sarnia refinery, in southern Ontario. Besides making Albertan crude oil available in a part of Canada hitherto supplied by imports, the new pipeline is also enabling small quantities of Canadian oil to be supplied to nearby U.S. markets.

Recent approval has been given for the construction of another crude oil pipeline, with an initial capacity of 3,500,000 tons per annum and an ultimate capacity of about three times this amount, which will go from Alberta across the Rockies at Yellowhead Pass to Vancouver, British Columbia. Completion of this and other facilities—planned for 1954—will enable further increases to be made in Albertan output.

The post-war discoveries in Alberta have provided a stimulus to continued prospecting activities which are most intensive in this province. Apart from areas already mentioned, the search for oil is also proceeding in British Columbia, and reports of oil being discovered there were received late in 1951. Large areas of potential oil land are still untested in Canada, and further discoveries are to be expected, following the scientific exploration and more intensive drilling now being undertaken.

Canada possesses a further vast potential reserve of crude oil in the Athabaska tar sands of northern Alberta, whose existence was noted by one writer before the end of the 18th century. The tar sands cover an area variously estimated at some 10,000 to 30,000 square miles. In many places, the oil-impregnated sands lie on or near the surface, and they are easily mined and treated for the extraction of the oil. Some thousands of tons of oil have actually been produced experimentally and processed in a small local refinery, and in the autumn of 1951 the Albertan Government, anxious to promote the commercial development of the tar sands, gave facilities to technical experts from a number of countries to visit the area, and plans for experimental production on a commercial scale were announced in the spring of 1952. In the past, however, the cost of operations has proved to be substantially above that of securing similar products from crude

The Subis drilling location on the Niah river, Sarawak, 35 miles from the Miri Oilfields. (A Shell photograph.)

A scene in the Trinidad oilfields. In the foreground a light derrick covers a producing well while the heavier derrick in the background is over a drilling well.

oil from pumping or flowing wells, and it is difficult, therefore, to appraise the true value of the tar sands as a future source of oil supply.

Apart from its oil resources, Canada has also large supplies of natural gas, found both in conjunction with oil and in separate fields. As with oil, the most important gas reserves are found in Alberta, where natural gas is used quite extensively for town lighting and for industrial and other purposes.

British Borneo

British Borneo, which includes the territories of British North Borneo, Brunei, and Sarawak, forms the northern part of the island of Borneo, the southern—and major—portion of which is included in Indonesia. Both parts of Borneo produce oil, supplies in the north coming from the Miri field in Sarawak and the Seria field in the State of Brunei.

The Miri oilfield was discovered in 1910, and output reached a peak of about 700,000 tons a year between 1926 and 1930. Production then began to decline, but the expanding output from the Seria oilfield more than compensated for this. The latter field lies on the coast of the South China Sea, and was discovered in 1929, but its development was delayed at first by the economic depression of the 1930's. By 1938, production of the Seria field had been raised to more than 700,000 tons, while that of Miri had declined to a little over 200,000 tons.

Oil production in British Borneo was seriously interrupted by the war, and after the Japanese retreat in 1945, production had to be built up again almost from nothing. In the Miri field, production is still well below the pre-war level, and amounts to about 50,000 tons a year, but in the Seria oilfield output is from comparatively few wells, each having a high yield, so that it was possible to increase the flow of oil very rapidly with the minimum of drilling. Seria has proved one of the most important oilfields so far discovered in the Commonwealth. It extends for eight miles along the shore and one-and-a-half miles inland; offshore wells have been drilled from piers extending out to sea. The rapid post-war development of the field has raised production in British Borneo far above the level of 1938 and before the end of 1948 had made it the largest oil-producing country in the Commonwealth. Although this position is now held by Canada, British

McNeish blow cases at a gas separator station in Trinidad. Oil from the separators flows into the blow case and when the oil reaches a predetermined weight a valve is tripped and admits a charge of gas which blows the oil to storage. A counter records the number of times the cases discharge.

Borneo's output, at 5,000,000 tons a year, is nearly double that for 1948.

The value of this achievement was enhanced by the post-war shortage of oil supplies, and by the slow recovery of the oil industry elsewhere in the Far East, where political disturbances caused the repair of war-time damage to be delayed and where production was still well below the pre-war level until 1950. Although there is no longer a general world shortage of oil, the production of British Borneo is of considerable importance to Far Eastern and sterling economy. As in most other oil-producing areas, exploration and drilling are still being pushed ahead in British Borneo.

Trinidad

The island of Trinidad first attracted attention on account of its "Pitch Lake", which was remarked upon by both Christopher Columbus, who in 1498 caulked his ships with Trinidad pitch, and Sir Walter Raleigh, who called at Trinidad almost a hundred years later. The asphalt from this lake is still dug out and forms one of Trinidad's exports to the United Kingdom, where it has long been used for road-making and other purposes.

The oilfields, however, are of much more recent discovery: abortive attempts were made to produce oil in Trinidad in the last century, but commercial production only started in 1909. The main centre of the oil industry is in the south-west of the island, though minor fields have been discovered elsewhere. In all, about twenty oilfields are now producing, but these are generally of medium depth, of small size, and in no way comparable, for instance, to those of Venezuela, whose most eastern fields lie only a few miles away across the Gulf of Paria, which separates Venezuela from Trinidad. Venezuela produced about 90 million tons of crude oil in 1951 and Trinidad only some 3 million tons. But as Trinidad has only a small domestic demand, most of the products from its crude oil—which is refined locally—are exported. Despite its comparatively small output, for many years Trinidad was the largest oil producer in the Commonwealth, only losing its position to British Borneo towards the end of 1948.

After over 40 years of intensive development of Trinidad's oil industry the prospects of discovering an oilfield of the Venezuelan type seem rather remote. Nevertheless, exploration still

continues on land, whilst marine areas —in which some preliminary surveys have already been made—provide new areas where the search for fresh reserves can be carried out with reasonable prospects of discovering fresh oil supplies.

India and Pakistan

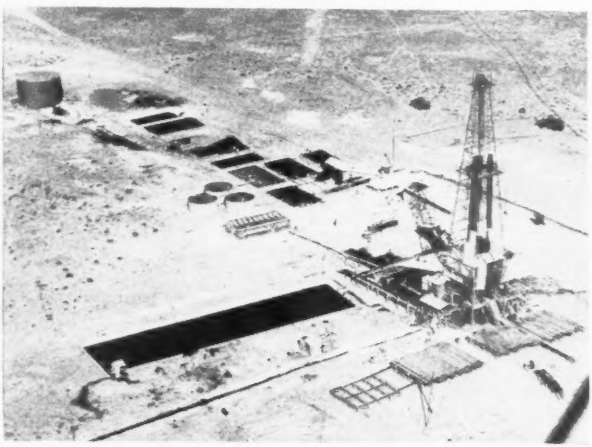
Small quantities of oil have been produced for many years in Upper Assam and in the Punjab. In 1947 the former oilfields became part of India, while the Punjab oil-producing areas were incorporated in Pakistan.

India's only producing oilfield is at Digboi in north-east Assam. Traces of oil in Upper Assam aroused interest more than 100 years ago, and in 1867 drilling began, but this proved unsuccessful and several later attempts to find oil in commercial quantities also failed. Finally, in 1890, the Digboi oilfield was discovered. Although another small field, discovered in 1916, was developed, this has now ceased production, and Digboi is responsible for the entire Indian output. As in other areas, exploration for oil continues in India.

In the Punjab, which is responsible for Pakistan's production, exploration began in the 1860's, but the first important discovery of oil was in 1915, at Khaur. Other oilfields have since been found at Dhulian (1934), Joya Mair (1944), and Balkassar (1946). The output from Khaur and Dhulian is steadily declining, but in the Joya Mair and Balkassar fields, production is increasing. An energetic programme of oil prospecting is at present being carried out in Pakistan.

Other Countries

Apart from the oilfields already mentioned, there is a small British production of about 45,000 tons a year —coming almost entirely from Eakring, Nottinghamshire, although there is also a very small contribution from Formby, Lancashire, and a little from Dalkeith, near Edinburgh. Elsewhere in the Commonwealth a few traces only of oil have been found, e.g., in New Zealand and Barbados. For some years there has also been an Australian production of a few hundred tons of oil a year in the Lakes Entrance field, 200 miles east of Melbourne, where oil is produced from horizontal wells, which are drilled off a 10 ft shaft sunk to a depth of 1,200 feet.



In West Pakistan. Lakhra Well No. 1 viewed from the air showing the modern 136-foot derrick, the mud-cooling pond at bottom left and mud tanks and pits at top left.

In the English oilfields. Three producing wells in the Eakring, Nottinghamshire, oilfields.

Oil from Shale

In contrast to their limited resources of petroleum, both Britain and other Commonwealth countries are rich in oil-bearing shale. It occurs in particularly large quantities in Canada, Australia, and Tasmania. The production of shale oil is relatively expensive, however, and at present its products can compete with those of petroleum only under exceptionally favourable conditions. In Scotland, where the shale oil industry has now been in operation for over a century, more than 100,000 tons of oil are extracted each year from deposits in West Lothian and Midlothian. Shale oil is also produced in the Transvaal, South Africa, and for some years there was a small production in New South Wales, Australia. The chief value of shale deposits is in providing an alternative source of oil products if the cost of producing petroleum should increase unduly or the world's oil supplies prove insufficient for its needs.

Search for New Oilfields

The oil industry's present search for new oilfields extends to many parts of the Commonwealth. Besides Canada, British Borneo, Trinidad, India and Pakistan, new areas are also being prospected. In Nigeria, for example, £1,500,000 has already been spent on the search for oil, and exploration work is being actively pursued in various parts of a 60,000 square mile concession. The first deep test well ever to be drilled in the country was begun in the latter half of 1951. Among other areas where the oil industry is investigating the possibility of the existence of oil reserves are the Gold Coast, Somaliland, Kenya, Tanganyika, Barbadoes and British Honduras.

Another area of considerable activity is Papua, in New Guinea, where geological air surveys have been carried out over 28,000 square miles of territory and a number of deep bore-holes have been drilled, including one that reached a depth of over 12,000 feet.

Since the war, exploration work has been carried out in Australia by both British and American, as well as local oil interests. The work done includes geological and geophysical surveys and drilling, and the areas covered include parts of Western Australia, South Australia, Queensland, and New South Wales. Up to the end of 1951, however, no oil discoveries had been reported in any of these areas.

These widespread exploration activities, even if successful, cannot affect the present oil position: for some years at least, the Commonwealth, which, like most parts of the world, has a rising oil demand, must remain increasingly dependent on imports for its oil supplies. This fact enhances the value of the vast operations of British companies, who, from oil concessions

in the Caribbean, the Middle East, and other regions, supply a large proportion of the total needs of the Commonwealth.

Refining of Oil

Though crude oil production is comparatively small in the Commonwealth, there is a large and expanding oil refining industry, which is already providing—from indigenous or imported supplies of crude—roughly three-quarters of Commonwealth needs of finished products. In this respect Great Britain has taken the lead, for the vast post-war programme had, by the beginning of 1952, raised total British refining capacity to an annual level of over 20 million tons. New U.K. refineries include Fawley, near Southampton—the largest refinery in Europe, with a capacity of 5,500,000 tons, later to be increased to 6,500,000 tons. Other major English refineries are situated at Stanlow on the Manchester Ship Canal, at Shell Haven on the Thames, and at Heysham, at Morecambe Bay, a few miles north of Blackpool. These three plants together are processing about 8,500,000 tons of crude oil annually. Wales possesses one refinery at Llandarcy, not far from Swansea, and there is a large Scottish plant at Grangemouth, near Edinburgh; at the end of 1951 these were operating at capacities of 4,000,000 tons per annum and 2,500,000 tons per annum respectively. Besides these principal ones, there are several small refineries in Britain and an important new plant, known as the Kent refinery, is being constructed on the Isle of Grain—this will have an ultimate capacity of 4,000,000 tons when in full operation in mid-1953. Yet another new plant, with a capacity of 850,000 tons per annum and intended primarily to produce lubricants, is expected to come into operation at Coryton, on the Thames, early in 1953. Thus, by 1954, total British refining capacity is likely to reach an annual level of 26,500,000 tons of crude oil—as against a comparable figure of only 2,500,000 tons in 1947.

Of almost equal importance is Canada's oil refining industry, for this also

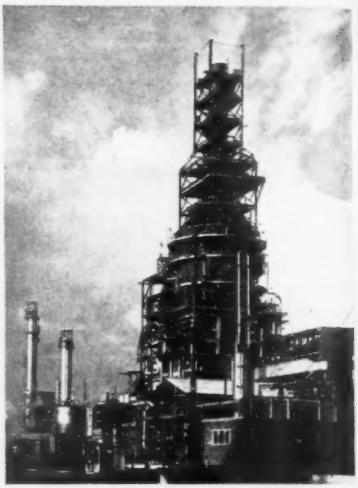
Camp construction at Wana, Papua, the only transport being the narrow gauge railway from store houses to the partly-built derrick. (An Anglo-Iranian photograph.)

amounted at the end of 1951 to almost 20,000,000 tons of annual capacity. The principal refining centres are situated in Canada's main industrial region in the eastern provinces, important plants being in the neighbourhood of Montreal and of Sarnia, on Lake Huron, where even before the war there were large refineries operating on imported crude oil. Now that the long pipeline from Edmonton to Lake Superior is in operation, Albertan crude oil constitutes the overwhelming proportion of supplies to Sarnia, where is located Canada's largest single refinery, whose pre-war capacity of just over 1,000,000 tons p.a. is being increased to about 3,500,000 tons p.a. by the end of 1952. Other Canadian refineries are at Edmonton, in the heart of the Alberta oilfields, and at Regina, Saskatchewan, which is on the route of the pipeline from Alberta to the Great Lakes, while there are also some small refineries in Vancouver, British Columbia, which at present operate on crude oil imported from California. It is proposed to increase refinery capacity in the Vancouver area in connexion with the construction of the pipeline from Alberta to British Columbia.

Trinidad possesses two major refineries—at Pointe-a-Pierre and at Point Fortin, both on the south-west coast. Since their combined capacity, of just over 5,000,000 tons annually, exceeds indigenous production of crude oil, they operate partially on imports, which are derived almost entirely from nearby Venezuela.

The only other major refining plant in the Commonwealth at present is at Lutong, Sarawak. The original refinery, destroyed during the war, has been replaced by a new and larger plant, processing about 2,000,000 tons of crude oil per annum. Other small refineries exist in India and Australia, and in both these countries major plants are planned. In Australia, four refineries are to be constructed, with a total capacity of about 6,000,000 tons p.a.; the largest, to be erected at Fremantle, will handle some 3,000,000 tons of crude annually. In India, plans have been announced for constructing two refineries in the Bombay area, while a third plant is under consideration. Yet another refinery, to process 750,000 tons of crude oil annually, is to be built in Durban, South Africa; it will come into operation in late 1953 or early 1954. In addition, refineries are projected for Aden and Pakistan—the first of which may possibly have a capacity of as much as 5,000,000 tons p.a.

The development of refinery capacity is already proving a factor of considerable economic importance to Britain and the Commonwealth. It is an illustration of the oil industry's post-war practice, that so many plants have been built near major oil markets, rather than in centres of crude oil production.



A Shell photograph.

Stanlow refinery's newest cat cracker which came into commercial production early this year, turns out products at a rate of more than a million tons a year.

MODERN TECHNIQUES IN PETROLEUM TESTING

X. MECHANICAL TESTS FOR LUBRICANTS

By H. L. BINGHAM*

Introduction

The analytical and physical tests normally employed for the control of lubricant quality provide essential data by which products may be judged and compared. The complex nature of lubrication, particularly when boundary, or part boundary and part hydrodynamic lubrication conditions are considered, does not, however, lend itself to easy solution by these methods. The suitability of an oil is then best judged by its performance in service. While service tests give the true criterion of oil quality, they are usually expensive and are invariably of long duration. The many uncontrolled variables, also, lead to difficulties in the interpretation of the data with tests of limited scope. Only by extensive tests in a wide field, in conjunction with a statistical approach to the problem, can the most reliable data be obtained. The magnitude of such a task is readily appreciated, and, for this reason, efforts are usually directed towards the development of the more simple laboratory rig with which controlled tests on quality may be made. Most laboratory rigs are designed to simulate as closely as possible the kinematics and loading of the service mechanism itself; frequently the test specimens used are selected commercial parts; but simple specimens also are sometimes employed so that, by their relative ease of manufacture to close dimensional tolerances and known physical properties, the variables in the test due to manufacturing errors are virtually eliminated. Usually, the choice of operating conditions for the laboratory rig is arranged to give an accelerated breakdown of the oil so that results are obtained in a reasonable time.

The mechanical testing of lubricants covers a very wide field embracing many products used in industrial, aviation, and certain marine and automotive applications. It is proposed to deal only with those tests used for gear oils, cutting fluids, aviation gas turbine oils, and hydraulic fluids.

Gear Oils

As progress has been made in gear design and manufacturing methods, the trends have been towards increased tooth loadings and higher speeds. Such changes react on the lubricant and are reflected by its ability to meet the increased duties; emphasis is given to load-carrying capacity or the property of the oil to withstand film rupture when subjected to high pressures in combination with a high sliding velocity between the moving surfaces. Most gear oil applications are adequately covered by plain mineral oils or mineral oils containing a small percentage of fatty material; the more stringent duties, however, require extreme pressure additive-containing oils. A notable example of this latter requirement is the automotive hypoid gear in which an inherent high sliding velocity between the teeth is coupled with relatively high tooth pressures.

For the measurement of the load-carrying capacities of oils, many laboratory machines have been developed. The SAE, Timken, Four Ball, Falex and Almen machines, shown diagrammatically in Fig. 1, have been described by West.[1] Although such machines were introduced many years ago, they are currently employed for laboratory

*Anglo-Iranian Oil Co.

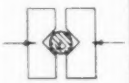
SAE MACHINE	TIMKEN MACHINE	FOUR BALL MACHINE	FALEX MACHINE	ALMEN MACHINE
				
1⅜ CUPS	1⅜ CUP	½ DIA. BALLS	¼ DIA. ROD	¼ DIA. ROD
1000 R.P.M.	800 R.P.M.	1500 R.P.M.	290 R.P.M.	600 R.P.M.
RUBBING VELOCITY 475 FT. PER MIN.	RUBBING VELOCITY 400 FT. PER MIN.	RUBBING VELOCITY 115 FT. PER MIN.	RUBBING VELOCITY 19 FT. PER MIN.	RUBBING VELOCITY 39.2 FT. PER MIN.

Fig. 1.

tests and it will be useful to describe them briefly here.

The SAE machine uses two cylindrical test specimens which are rotated in line contact with each other and in opposite directions. Provision is made for controlling the speed of rotation, the sliding velocity, and the rate of application of the load at the line contact between the rotating cylinders. In testing a lubricant the load at which rupture of the oil film takes place, producing a scoring of the test specimen surfaces, is taken as an index of load-carrying capacity (CRC designation L-17-545).

In the Timken machine, a flat test piece is loaded against a rotating cylindrical test specimen and the load-carrying capacity of the lubricant is given as the maximum load that can be applied to the specimens without causing scoring or pick-up of metal. The CRC test designation for this machine is L-18-545.

The Four Ball machine uses half-inch steel ball bearings as specimens. One ball, clamped in a chuck at the bottom of a vertical driving hub, is rotated in the cavity formed when three other balls are fixed together in the lubricant container. When pressure is applied to the lower three balls, wear spots are formed at the points of contact. In the usual test procedure the wear/load characteristics of the oil are determined by making one-minute runs at each of a series of loads and plotting on logarithmic paper the mean diameter of the wear spots against load. Curves for typical oils are shown in Fig. 2. A friction-recording apparatus is fitted to the machine from which the onset and magnitude of the seizure or scuffing that occurs in the ball system at the higher loads can be obtained. Two methods of rating for load-carrying capacity are generally used: the 2½ second seizure delay load,[2] obtained by interpolation on a curve relating the time in seconds for seizure from the commencement of the run, and load, and the Mean Hertz Load (Federal Method 650.3) which gives an overall appreciation of the wear/load curve.

While machines of the above kind are extremely useful for screening purposes in the development of new products and, in more fundamental work, for providing information on the behaviour of oils examined under fixed conditions of operation, the results are

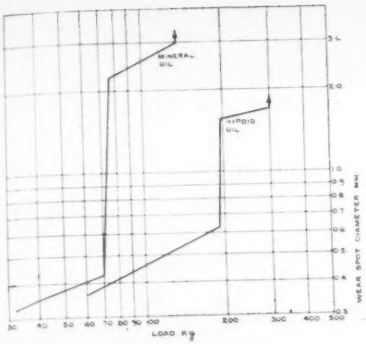


Fig. 2.

not generally in agreement with service data.

A further laboratory rig, used extensively for the evaluation of load-carrying capacity, is the IAE 3½-inch gear machine. By the use of two spur gears as specimens, the lubricant is tested under conditions which more nearly approach those met in practice. Load is applied to the gears by torsion in shafts which, in combination with the

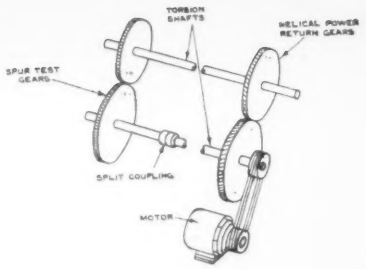


Fig. 3.

test gears and a pair of power return gears, form a power circulatory system. The machine is shown diagrammatically in Fig. 3. Load is applied incrementally to the gears during regulated shut-down periods, and the minimum load to give tooth profile scuffing is taken as a measure of the load-carrying ability of the lubricant.

Typical results from the SAE, Four Ball and IAE gear machines for a series of oils are shown in Table I. An examination of the table shows the unusual behaviour of a powerful extreme pressure

TABLE I

Oil	*IAE 3½ inch gear machine Mean scuffing load lb**	*SAE machine Mean scoring load lb†*	*Four-ball machine, 2½ sec seizure delay*
Mineral oil A (35 cs visc at 210 F)	89	59	87
Mineral oil A + 6% rape oil	123	54	85
Mineral oil A + 5% sulphurized fatty oil	—	63½	110
Mineral oil A + 10% hypoid additive (a)	—	268	122
Mineral oil A + 10% hypoid additive (b)	—	69	155
Castor oil	147½	43	115
Mineral oil B (25 cs visc at 210 F)	87½	—	98
Mineral oil C (11 cs visc at 210 F)	48¾	—	82
Mineral oil D (2.5 cs visc at 210 F)	26¼	—	51

*To convert to lb/inch face width, multiply by 61.04.
†Figures given are loads on spring balance. To convert to loads on cups multiply by 10.

oil (additive (b)) in the SAE machine; the result given is very little better than the base oil. This well illustrates the caution that is necessary in the interpretation of data given by an isolated test, and indicates that a more reliable judgment of oil behaviour is given by an appreciation of the results from two, or preferably more, different rigs.

In the evaluation of hypoid oils to the U.S. army specification MIL-L-2105, full-scale hypoid axle tests are made. The axles used are selected from current production, and in this way are typical of those for which the lubricant is used in service. Apart from the increased severity of the test operating conditions from those found in practice, an extra duty is imposed by the omission of a running-in period for the hypoid gears.

The two major requirements of this specification are qualification of the oil by a high-speed test (CRC designation L-19-645), conducted either on the road or with a vehicle loaded by a chassis dynamometer, and a high torque/low speed test (CRC designation L-20-545) which is carried out on a laboratory rig.

The high speed test, directed towards an assessment of the load-carrying characteristics of the oil, uses a Chevrolet passenger car in which a new test axle has been installed. After running between 5 and 25 miles at a speed not exceeding 25 m.p.h., full throttle acceleration in top gear is carried out to 40 m.p.h. The throttle is then closed and, with the clutch engaged, the vehicle is coasted to 10 m.p.h. The acceleration and deceleration are repeated three more times. A gradual acceleration in top gear to 60 m.p.h. is then made, and at 60 m.p.h. the throttle is opened wide for acceleration up to 80 m.p.h. at which speed the throttle is immediately closed and the vehicle coasted to 60 m.p.h. with the clutch engaged. This procedure, between 60 and 80 m.p.h. is repeated a total of ten times. On completion, the oil is drained and the crown wheel and pinion assembly removed from the axle. An unsatisfactory lubricant is shown by scuffing on either the drive or coast sides of the teeth of these parts.

The high torque/low speed test is used for determining the load-carrying, wear, stability and corrosion characteristics of an oil. A new Chrysler ¾-ton army truck hypoid rear-axle carrier is used for each test. The laboratory rig is arranged with a power supply unit for coupling to the pinion shaft and absorption dynamometers at the axle shafts. Water-cooling of the axle casing is provided by means of a spray which is controlled to give a cyclically varying oil temperature between 200 and 250°F. With a crown wheel speed of 62 r.p.m. and crown wheel torque of 6,000 inch-lb, the rig is operated until, with no water-cooling of the axle casing, an oil temperature of 140°F is reached. An inspection of the tooth contact surfaces is then made. If satisfactory, the torque is increased to 32,311 inch-lb; when the oil temperature reaches 250°F, the water for cooling the axle is turned on. The test is continued for 30 hours after which time the axle is dismantled and the various parts examined. Failure of the oil is judged in terms of the degree of wear, scuffing, or other tooth surface breakdown effects, the amount of sludging or deposits formed, and the extent of corrosion of the parts.

The importance of the wear properties of a lubricating oil is brought out in this test. It is known that oils incorporating certain hypoid additives exhibit very good load-carrying capacities but only at the expense of relatively heavy wear. Where preliminary wear tests are required, the simpler laboratory machines are in many cases very useful. Some easing of the operating conditions from those used for load-capacity tests is usually necessary, but with the Four Ball, SAE and Timken machines this is easily accomplished.

Cutting Oils

Cutting fluids are of two general types: soluble oils, in which a small amount of the concentrated base material is mixed with water to form an oil in water emulsion, and neat oils which are generally a mineral oil or a fatty oil. Both soluble and neat oils may have additives incorporated in them to impart lubrication characteristics of an extreme pressure kind. The choice of a cutting fluid for a machining operation is dependent on many conditions; where heavy-duty cutting has to be carried out or a maximum tool life between regrinds is necessary, the neat oils or additive-containing oils are generally used.

Of the extensive work carried out in the field of metal cutting since the work of F. W. Taylor,[3] the investigations have chiefly been concerned with the machinability of metals. More emphasis in recent years has been given to cutting fluids, but as far as is known, no one of the many mechanical tests which have been developed is recognized as a standard method for cutting fluid rating purposes. The most satisfactory way to evaluate a cutting fluid is to use a metal cutting operation in the laboratory similar to that for which the fluid is to be used commercially. Of the many machining methods, possibly drilling and turning are the two most favoured. As in tests on other products, it is necessary to accelerate breakdown of the fluid by operating the rigs under conditions more severe than those met in practice so that results are given in a reasonable time.

In drilling tests, the method used by the Production Engineering Research Association[4] is to determine drill life in terms of the number of holes drilled before point failure occurs. Conditions of drill speed and feed are chosen to give a medium life test, i.e. the holes to failure are arranged to be within 40 and 150. A dynamometer is used for measuring the thrust and torque present in the test, and point failure is indicated by an appreciable rise in torque caused by wear on the cutting edges and drill lands.

The methods used in turning can be broadly classified into two groups: rough turning and finish turning. In rough turning the criteria used for test purposes are rate of stock removal, efficiency of stock removal in terms of horse-power consumed, and tool life. Similarly for finish turning, the criteria are surface finish, dimensional accuracy and, as before, tool life, which is common to both. Where cemented carbide tools are used, the life expressed in terms of wear at the nose of the tool when a fixed peripheral length of cut has been taken, and with high-speed steel tools, the time required to give a collapse of the cutting edge, are customary measurements. The deterioration in surface finish of the workpiece caused by tool wear, and the extent of cratering on the face of cemented carbide tools are other methods described by Moir *et al*[5] and Eatough.[6] Cratering and nose wear are illustrated in Fig. 4.

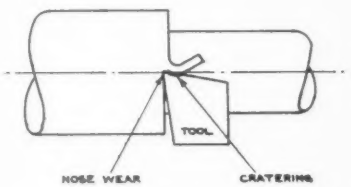


Fig. 4.

In the determination of the efficiency of stock removal, the power used in the cutting operation is measured either by a wattmeter in the motor circuit or by the forces present at the tool during cutting. Three component forces are present at the cutting edge: a tangential force perpendicular to the tool face, a thrust force on the tool acting in a radial direction from the workpiece, and a transverse force due to the feed.

Measurement of these forces is by tool deflections through elements of electrical (inductance or capacity), hydraulic, or mechanical types.

Where the differences in cutting fluid performance are likely to be small, it is essential that the closest degree of control should be exercised over all extraneous variables. Cutting tools should be selected for uniformity of physical and metallurgical properties; consistency of grain structure with freedom from inclusions is a requirement of the test material. The reproduction of tool cutting edges should be within very close dimensional limits, and peripheral cutting speed (for constant speed tests), feed, depth of cut, cutting fluid temperature and method of application should all be maintained constant. It is only by attention to such details that fairly good test sensitivity is achieved.

Aviation Gas Turbine Oils

The lubrication requirements of the aviation turbine engine are exacting owing to the wide range of temperature encountered in operation. A temperature of $-60^{\circ}C$ has been quoted as one extreme. Under extremely cold conditions, the oil viscosity should not be such as to give excessive starting torques, or to prevent satisfactory operation of the pumps, or to restrict the feeds to gear drives. At the high temperatures, which may lie between 220 and $260^{\circ}C$ for bearings, adequate lubrication properties are required for the bearings and auxiliary gear drives. With the turbo-propeller type of unit, and its attendant large ratio reduction gearing, emphasis has been given to load-carrying ability. Stability of the lubricant at high temperatures is especially important with regard to ball bearings. Unless suitable precautions are taken on shutdown of the turbine unit, a heat-soaking effect of the main bearings, by conduction from the hot turbine rotor, takes place and a temperature rise of about $40^{\circ}C$ may occur. This may result in a breakdown of the oil to form gummy or carbonaceous material on the bearing surfaces; and the restrictions thus formed to the proper operation of the bearing are very likely to lead to early bearing failure on the subsequent start-up.

Of the many laboratory machines available for load-carrying capacity tests, the IAE $3\frac{1}{4}$-inch gear machine is probably the most useful for these oils. Like most tests made with such rigs, the results obtained can at the best serve only as a guide to the possible behaviour of the lubricant in service, and in doubtful cases, tests with full-scale gear boxes may be necessary.

The behaviour of the lubricant in high-speed ball bearings is one that requires special study. Most bearing failures are associated with the cage, either by seizure with the race for race-located cages, or by seizure with the balls. Not only is the choice of cage material important, but also the oil has to provide satisfactory lubrication under high speed conditions when centrifugal action tends to throw off oil from the cage. For such investigations, bearing test rigs are used which are capable of matching in both speeds and loads the conditions met in full-scale turbine units.

The most simple rigs are those used to determine the life of bearings when operated at fixed speed and load conditions. Results of endurance tests on bearings of the same size and type are found to vary very appreciably despite the high degree of precision used in their manufacture. The only satisfactory approach to this problem is to carry out many tests and to analyse the results by statistical methods.

For a detailed examination of bearing and lubricant behaviour, more elaborate rigs have been developed.

The rig with which the author is familiar has a variable speed drive to the main shaft with a maximum speed

of 20,000 r.p.m. Loading of the test bearings is by dead-weight lever systems with capacities up to 15,000 lb both radial and thrust. Movement of the whole of the outer housing of the test bearings during operation is restrained by a simple lever system which when balanced provides a means for the measurement of the frictional torque present in the bearings. Bearing temperatures are measured by thermocouples fitted to the outer and inner races. The test lubricant is fed to the bearings either from a jet or spray depending on requirements, and the flow rate and inlet temperature are controlled. With rigs of this type, the variation in bearing temperature and frictional torque may be studied as load, speed, oil flow rate or method of application of the oil to the bearing is changed.

Hydraulic Oils

These are chiefly petroleum-base materials, but for certain duties in aircraft applications non-mineral oil types are used. One of the requirements of aircraft fluids is stability under repeated shearing action; in some specifications, tests to determine the lubrication and anti-wear properties of the fluid are called for. For automotive hydraulic oils, the evaluation of the lubrication quality of the fluid when used in brake systems is determined by a stroking test.

In Ministry of Supply specification DTD 585, the shear stability of a hydraulic oil is determined by pumping the oil through a labyrinth restrictor for 168 hours. The oil pressure and temperature are maintained at 800 p.s.i. and 100°F respectively. An identical test is then made with a reference oil and the merits of the test oil are judged in relation to this. An examination for viscosity change, darkening, separation of gummy materials, and sludge formation is made after each test.

The wear and lubrication characteristics of a fluid are determined in U.S. military specification MIL-F-7100 by tests with a Pesco gear-type pump operated with a fluid pressure of 1,500 p.s.i. and temperature of 160°F for 500 hours. The assessment of the fluid is made in terms of the loss in weight of the pump parts.

A brake system, comprising a master cylinder and four brake assemblies, is used for the stroking test to CRC procedure L-14-545. All rubber parts used are of natural rubber. The master cylinder is operated at a rate of 1,000 strokes per hour and the test is continued for a total of 150,000 strokes. The condition of the parts is then noted with reference to corrosion, scuffing, etc., and the amount of wear of the master and wheel cylinders is measured.

Acknowledgment

The author wishes to thank the Chairman of the Anglo-Iranian Oil Co for permission to publish this article.

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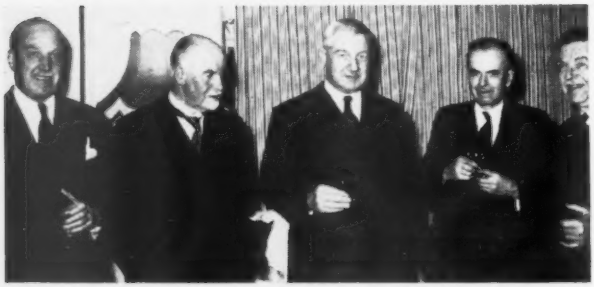
Electronic Control. National Oil Refineries new sulphur dioxide extraction plant at Llandarcy is believed to be the first refinery unit in the world to be completely controlled electronically. Measurement and control instruments operate on the Evershed Electronic Repeater System.

COUNCIL COMMENTARY



Following the Annual General Meeting of the Institute on April 24 the retiring president, Mr C. A. P. Southwell, M.C., was entertained at dinner by Members of Council. He is seen here (left) with Mr T. Dewhurst (president 1933-5), Mr H. S. Gibson, C.B.E., the new president, Prof. F. H. Garner, O.B.E. (president, 1944-6; and honorary editor), and Lt.-Col. S. J. M. Auld, O.B.E., M.C. (president, 1937-9).

At the Council meeting held on April 9 the chair was taken by J. S. Parker, Vice-President.

Arrangements for the summer meeting are proceeding satisfactorily and several suggestions for speakers are being considered. One of the speakers will be H. S. Gibson, our new President. It is probable that all the talks will be given during one morning.

The Transport Executive have applied for collective membership of the Institute and have been accepted by the Council. Four of their constituent bodies are concerned—The Railway Executive, London Transport Executive, Road Haulage Executive, and Docks and Inland Waterways.

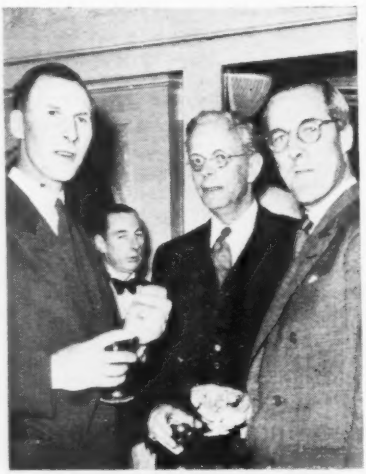
The Branches Committee had an interesting report to submit to Council. All Branches are in a very flourishing state.

The attendance at meetings in Trinidad have shown some falling off and Mr Pracy has undertaken to look into this and if possible ascertain the causes.

The Northern Branch has for some time consisted entirely of Corporate members of the Institute. They have now decided to review this policy and the question of introducing local branch members is to be considered at an Extraordinary General Meeting in the near future.

Birmingham is very active and are inviting to their meetings corporate members of the Institute living in their area.

Stanlow Branch now boast 197 members of which 144 are corporate



Among those also present at the dinner were (left to right) C. S. Windebank, M. A. L. Banks, and W. S. Ault.

members and 53 are branch members. Two visits to local works have been arranged for the summer.

South Wales have recently undertaken a membership drive which has produced nearly 60 new members. Their latest figures show a total of 161 members made up of 61 corporate, 67 branch and 12 students.

The present session has been a satisfactory one for the Scottish Branch and all appears to be going well.

London report a total of 337 members, 186 corporate and 151 branch. An endeavour is to be made to persuade more of their members to subscribe to the *IP Review*.

Fawley have had an average attendance of 60 at their meetings and report a satisfactory session.

The rules of the two new branches—Persian Gulf and South Eastern—have been considered and approved after a few minor alterations.

Council have agreed to allocate £500 to the Branches for the year 1952/3, of which £330 has been allotted and the remainder will be held by Branches Committee as a central fund on which Branches can draw if necessary.

Mr E. A. Evans has been asked to become Branches Lecturer for 1952 and 1953 and is giving the matter his consideration.

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FINA PETROLEUM PRODUCTS

It is officially announced that Fina Petroleum Products Ltd. have, as from March 31, 1952, acquired from Harris & Dixon (Oil) Ltd. the whole of the share capital of Watsons Petroleum Co. Ltd. of Preston, hitherto sole distributors of Fina Petroleum and other products in the West of England and Wales. At the same time Fina also acquired the storages and business of New Western Oil Storages Ltd. from the same company, and will operate the ocean installations through the subsidiary Fina Oil Wharves Ltd.

The foregoing refers to the entire oil distributing, operational and storage facilities in the United Kingdom formerly owned and controlled by Harris & Dixon (Oil) Ltd. The wholesale oil brokering business of Harris & Dixon (Oil) Ltd., remains unaffected by the purchase, and the transaction affects in no way the shipping, bunkering, and insurance business of Harris & Dixon Ltd.

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RESETTLEMENT OF AIOC STAFF

To look after the interests of the 2600 members of the British staff of AIOC formerly employed in Abadan, a special Resettlement Panel was formed. Of those who returned from Persia last summer, a number have joined the home staff and others have been transferred to associated or subsidiary companies. The services of some 2000 employees, including a proportion of the home staff, have so far been terminated. Of these, about 1100 have applied for the Panel's aid and approximately 600 have already found jobs through the Panel's intermediacy or their own efforts.

Ex-gratia payments have been made to staff whose service has been ended before they reached pension age.

In cases where, owing to long service overseas, ex-employees have lost touch with current practice and technique in Britain, short refresher courses have been arranged at the company's expense.

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CANADIAN OIL PRODUCTION

Total production of crude petroleum in Canada during 1951 is estimated at 48,096,800 brl (value $121,407,550) by the Dominion Bureau of Statistics, compared with 29,043,788 brl ($84,619,937) in 1950. Natural gas output is estimated at 73,838,217 M.cu.ft. for 1951 ($6,504,237) against 67,822,230 M.cu.ft. ($6,433,041) in 1950.

AROUND THE BRANCHES

London Branch

On March 19 a meeting was held at Manson House, with the Branch Chairman N. E. F. Hitchcock presiding, to hear a paper read by P. M. de Veulle, editor of Petroleum Press Service, entitled "Oil—an agent of change".

The paper, which was illustrated with a number of slides, was of unusual interest in pointing not only to the by now fairly familiar picture of the rapid changes in both the technological and economic aspects of the oil industry itself, but also to the wider causes and effects of some of those changes—taking the subject into the broad field of human history and relationships. Beginning with a brief survey of the remarkable effects of the invention of the internal combustion engine in making the world smaller and also in bringing vast new possibilities of progress to underdeveloped countries, the speaker went on to show some of the metamorphoses which had been forced on the industry itself by economic developments outside and continued and rapid technical developments within. There followed a short estimate of the effect of the birth and development of the oil industry in some less-developed countries such as Venezuela and the new oil areas of the Middle East, where within an astonishingly short period of years, unimagined wealth had descended upon peoples accustomed to poverty or near-poverty, and the impact of technical facilities produced by much more advanced civilizations had raised problems which were by no means yet solved. As a final illustration of the widespread effects of the changes set in motion in one way and another by the influence of oil, Mr de Veulle quoted the far-reaching modifications in the international legal conception of territorial waters which were being imposed by the development of undersea drilling for oil in areas beyond the three-mile limit.

The paper was followed by a very keen discussion, at the conclusion of which a vote of thanks moved by G. E. Roberts was passed with enthusiasm.

At Manson House on the evening of April 22 a large audience of some 150 members and visitors met to hear a talk entitled "Fawley Refinery," by G. Noble, B.Sc., A.M.I.C.E., the manager of the refinery. The meeting was preceded by an extraordinary general meeting (at which also the Branch Chairman, N. E. F. Hitchcock, took the chair) the object of which was to propose and pass an alteration in one of the Branch's rules.

After a brief introduction, Mr Noble presented a series of very interesting colour lantern slides illustrating the various aspects of the vast Fawley project at the different stages of its construction. Together with Mr Noble's accompanying commentary, these slides gave an excellent impression of the scale of the operation and some of its difficulties and achievements, and to complete the picture the speaker ended by showing a film made by the Esso Film Unit illustrating the various phases of the construction almost up to the completion stage.

Following the film, questions were asked and Colonel Adlington then proposed a vote of thanks which was carried with acclamation.

This ended the formal business of the evening and the Chairman then welcomed the numerous visitors who had come to join members of the Branch in the second winter social function, the Fork Supper. Over 120 members and guests took part, and on this occasion, to the relief of the committee, not only the bar but also the buffet was adequate. Both were crowded from 7.30 onwards

and remained so in spite of the counter-attraction—also well patronized—of a programme of varied documentary films. The aim had been to organize a function which, while bringing together the largest possible number of members and guests from outside the Branch, would be quite informal. It was generally felt that the results justified the expectation and that the pattern should be a suitable one for similar functions in the future.

Scottish Branch

Preliminary planning for the proposed new colliery at Rothes, near Thornton, in the County of Fife, was described in an address given by George Mullin, Scottish division, National Coal Board, at the Engineering Centre, Glasgow, on April 1.

This colliery, when in full production, will be the largest in Scotland, and one of the largest in Great Britain.

The colliery is laid out for an output of 6,000 tons per day and will have a capacity to deal with 8,000 tons per day if need be. Its area covers approximately 10 square miles, and has reserves of coal of over 180,000,000 tons. The colliery will employ approximately 2,400 men and give an output per manshift of 47/50 cwt—the coal will be raised on two shifts. The colliery will be fully electrified.

The lay-out is designed for the horizon system of mining, some interesting and novel features being incorporated in the design.

The lecturer instanced some of the problems which had arisen in the course of construction and gave details of the sinking lay-out, the sinking winder, the sinking of the shafts, surface buildings, Koepe winders and winding arrangements.

A novel feature of the lay-out is that all machinery will be inside the main buildings and, apart from the locomotives for shunting loaded and empty wagons, no machinery will be visible from the outside.

South-Eastern Branch

On Tuesday evening May 6, 1952, the last meeting of the 1951-2 session of the South-Eastern Branch was held at the King's Head Hotel, Rochester, when an interesting programme of sound films was presented to a gathering of 115 members and visitors. The following films were shown: *The XXIst Monte Carlo Rally; Refining of oil; As old as the hills; Isle of Man TT Race* 1950; *The diesel story*.

The first meeting for the 1952-3 session will take place on Tuesday, September 2, 1952, but during the summer recess visits to places of interest are being organized.

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"THE GAS TURBINE GOES TO SEA"

The installation of the marine gas turbine in the tanker *Auris* and its subsequent successful sea trials were events of considerable moment in British marine history. To afford the layman a glimpse of the extensive organization, the exacting tests, the exhaustive checking and re-checking that went on behind the scenes before the gas turbine went to sea, Shell Film Unit have made a short film.

The major part of the film deals with the actual installation work in the *Auris* on Tyneside (appropriate background music, specially composed by Raymond Bennell, accompanies these sequences), and there are also shots of the gas turbine's journey by road from Rugby to the Tyne.

The film, which runs for 17 minutes, may be borrowed from Shell-Mex and B.P. and from Petroleum Films Bureau.

PERSONAL NOTES

C. G. Brook, M.Inst.Pet., has been appointed general manager of the National Benzole Co Ltd. Joining the company in 1920, Mr Brook became manager of the London division the following year and in 1949 was made assistant general manager.

W. A. Woodrow, F.Inst.Pet., who retired from the service of the Anglo-American Oil Co in July 1950, has recently returned to England after spending a year in Australia. He reports that he has benefited much from the change and travelled over 9000 miles in Australia.

New treasurer of ASTM is **Robert J. Painter,** a member of the Society's staff since 1931. He succeeds **John K. Rittenhouse,** who has retired after 43 years of service and who was ASTM's first full-time employee.

A recent visitor to the U.K. was Abdullah Mashnuk, editor of Ahlun Naft *(Iraq Petroleum Co's Arab magazine) seen here (left) with J. B. Edwardes, deputy head of the company's public relations department.*

First occupant of the newly-created post of Middle East adviser to Standard Oil Co (New Jersey) is **Paul J. Anderson** of the company's Producing Co-ordination department. He has been chairman of Jersey Standard's Middle East Committee for the past two years.

Henry T. Meadows, A.M.Inst.Pet., has been appointed by Guthrie, Murdoch & Co, ship repairers of Antwerp, to be their U.K. and Ireland representative.

T. A. Lumsden, Secretary of Esso Petroleum Co since 1945, was recently presented with his 30 years' service button by Leonard Sinclair, chairman and managing director.

M. J. Noone, formerly chief engineer of Whessoe Ltd of Darlington, has been appointed to the new post of manager of operations.

Charles Macdonald, for many years contracts manager of Wailes Dove Bitumastic Ltd., has been appointed to the company's board of directors.

George Koegler, Government Relations Counsel for Standard Oil Co. (New Jersey), has been appointed executive assistant to the company's president, Eugene Holman, in succession to David A. Shepard, who became a director last December. Mr Koegler is succeeded by Thomas E. Monaghan.

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COMPANY PRODUCTION—CRUDE OIL

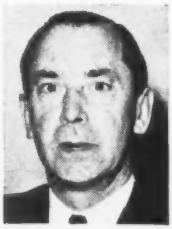
	1952	
	Feb.	*Mar.*
	tons	
Kuwait Oil Co . .	2,536,632	3,302,538
		Mar.
		brl
Trinidad Petroleum Development Co Ltd		258,376
British Controlled Oilfields Ltd		
Venezuela		
Western area		12,633
Central area		17,070
Kern Oil Co Ltd		
California		112,063
Trinidad		71,561

AIOC REFINERIES DEPARTMENT

G. E. Spearing

M. A. L. Banks

D. G. Smith


R. C. Thomson

H. W. Rigden

S. W. Adey

D. W. K. Barker

The Refineries Department of Anglo-Iranian Oil Co Ltd has recently been reorganized into six divisions under the general management of C. E. Spearing, F.Inst. Pet., with M. A. L. Banks, F.Inst.Pet., as deputy.

Each division will have its own manager and the following appointments have been made. Research and Development—D. G. Smith, M.Inst. Pet.; Engineering—R. C. Thomson, M.Inst.Pet.; United Kingdom—H. W. Rigden, A.M.Inst.Pet.; Middle East—S. W. Adey, A.M.Inst.Pet.; Australian—D. W. K. Barker; Continental—pending the appointment of a manager work is being co-ordinated by O. A. Bell, A.M.Inst.Pet., and C. Billingsley under the general direction of M. A. L. Banks.

★ ★ ★

C. LAURENCE WARWICK

It is with much regret that we record the sudden death on April 23 of C. L. Warwick, executive secretary of the ASTM and its administrative head since 1919. He had been active in the Society since 1909, was appointed secretary-treasurer in 1919 and in 1946 became executive secretary.

During September last Mr Warwick paid a visit to Europe and spent some time at the IP discussing the question of closer co-operation between the ASTM and the IP in regard to petroleum standardization. Those who met Mr Warwick were impressed with his personality and his broad outlook.

INDUSTRIAL DATA

An industrial section, including American books, periodicals, government documents and other literature in the fields of technology, engineering, management and trade, has been opened at the American Library, 41, Grosvenor Square, London, W.1 (Gro. 9000, Ex. 747 or 748). The library works in close co-operation with British technical libraries and specialized research agencies, and acts as liaison with appropriate agencies in the United States where information in its own collection is not sufficient. Books and other material can be borrowed by anyone in Great Britain.

PETROLEUM IN PARLIAMENT

Petrol Tax Receipts

In a written reply on April 22, the Chancellor of the Exchequer said that the estimated receipts from petrol tax from industry and agriculture for light hydrocarbon oils used for purposes other than transport were:

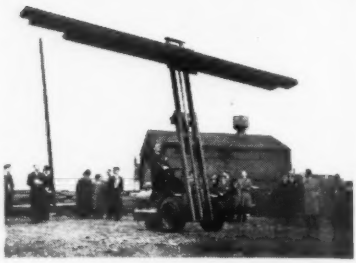
	Industry	*Agriculture*
	£ *million*	
1938-9 . .	3.3	0.4
1948-9 . .	5.2	1.7
1949-50 . .	5.2	1.9
1950-1 . .	10.8	4.1
1951-2 . .	14.3	5.3
1952-3 . . (expected)	19.8	7.5

White Spirit Duty

The Financial Secretary to the Treasury, in a written reply on April 29, confirmed that the increase in duty in light hydrocarbon oils would apply to white spirit used as a cleaning solvent.

The Rt. Hon. J. Selwyn Lloyd, C.B.E., Q.C., M.P., Minister of State at the Foreign Office, paid a visit recently to Stanlow refinery. He was photographed with (left) E. LeQ. Herbert, general manager of "Shell" Refining and Marketing Co., and (right) C. R. Middleton, general manager of Stanlow refinery.

NEW FORK TRUCK



A demonstration was recently staged at Dagenham of the new 1-ton Matbro fork truck, the "baby brother" of the two-ton model which Shell have bought for Brunei and IPC and BPC for the Middle East.

Designed by Mathew Bros and fitted with a standard Ford 10-h.p. industrial engine, the one-tonner is intended as an all-purpose truck, equally at home on the factory floor or out in the open, thus enabling loads to be conveyed from field to store in one movement.

Its manœuvrability was demonstrated by L. Mathew, who steered it up pot-holed slopes (it is claimed that it can tackle a gradient of 1 in 6 with full load over rough ground) and spun it round, taxi-wise, almost in its own length, on a stony, uneven surface. The model shown (22/12/P) has a mast which will lift from ground level up to 12 ft and can take a maximum load of 1900 lb. The demonstration included the lifting and carrying of a variety of loads including boxes of generators, 20-ft long baulks of timber, wheel castings and sacks of forks.

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FIRST FLUID HYDROFORMER

In April, construction began at Pan-Am Southern Corporation's Destrehan, Louisiana, refinery, of the world's first fluid hydroformer. Designed by the M. W. Kellogg Corporation, this 2000 barrel per day unit is scheduled for completion by August of this year.

THE ORIGIN OF PETROLEUM—II

By F. MORTON (Vice-President)

Whilst the two opposing theories of shallow depth of burial and deep burial attracted chemists and physicists to investigate the chemical changes involved, the geological attack on the problem was even more intense. This followed three main lines of attack. The first was an intensive search among all sedimentary rocks near to a known oilfield for evidence of deposits of the euxinic, or black shale type. The second was an investigation of the organic content of modern deposits and a study of the microbiology and the organic content of the offshore ocean depths, and the third a renewed study of the relationship between crude oil composition and stratigraphy. With these three main studies were allied the day-to-day field observations of exploitation and exploration geologists whose opinions and the supporting data, have been collected and edited by Parker and Van Tuyl.

Parker D. Trask (Director of the American Petroleum Institute Research Project on Source Beds) has examined the organic content of several thousand samples of ancient sediments ranging in age from Cambrian to Pliocene. The average organic content of these sediments is of the order of 1.5 per cent. Very few sediments in existing oilfields contain less than 0.5 per cent or more than 5 per cent of organic matter. The average organic content of recent sediments is about 2.5 per cent by wt. This varies considerably with the environment. In near shore marine sediments it varies from 1 to 7 per cent, being large in areas characterized by plentiful plankton. In some fresh water lakes it may be as high as 40 per cent, and in some deposits in the Black Sea it is 35 per cent. In typical ocean sediments far from land it is seldom in excess of 1 per cent.

Krecji Graf's view that a sediment must be very rich in organic matter in order to be a source bed was based on the belief that an excess of petroleum must be formed, before the oil can migrate, over and above that needed to saturate the clay particles which the oil might meet in the process of migration. Since the average difference of organic matter between modern and ancient sediments indicates a loss with age of approximately 40 per cent of the organic content, Trask does not consider that any of the ancient sediments examined can have originally contained much more than 10 per cent of organic matter. This is far below that postulated for "euxinic" or black shales. Nevertheless Trask believes that an organic content of from 5 to 10 per cent is probably necessary before a sediment could give rise to commercial accumulation of oil. Other factors investigated in this survey include the nitrogen and oxygen content of the organic material. These figures indicate a lower oxygen content than would normally be associated with natural fats, or at least suggest that the sediments associated with petroleum deposits have contained organic matter low in oxygen and not of a fatty nature.

The oceanographic studies of Zobell and his colleagues have shown that bacterial activity in marine deposits decreases very rapidly from the surface downwards. This is in agreement with the view of Trask who suggests that the organic matter originally deposited with the sediment would be used up by bacterial oxidation (to CO_2) unless the available oxygen is insufficient to support such an action. In Zobell's work it has been shown that the surface of the sediment can support some aerobic bacteria, but with increasing depth the quantity of bacteria decreases rapidly.

Zobell and his co-workers have devoted much time to the study of bacteria in relation to the destruction of and formation of petroleum. It was of course known that certain bacteria, yeasts, and moulds were capable of utilizing hydrocarbons such as petroleum, vaseline, naphthenes, phenols, cresols, etc. Methods for the disposal of phenolic effluents have been based on such processes. Lipman and Greenberg obtained a coccus, or coccobacillus from petroleum from a depth of 8700 ft which decomposed petroleum completely to carbon dioxide. The anaerobic decomposition of organic material by bacteria normally produces methane with minor quantities of high hydrocarbons. Neave and Russell, however, have reported up to 12 per cent of ethane in the gas produced by anaerobic bacteria in sewage, and Rawn and his co-workers have reported the presence of ethane, propane, pentane, and butadiene in these gases. The amount of the higher hydrocarbons is however very small and Zobell, Grant, and Hass give the following analysis of gas from the anaerobic decomposition of sewage sludge:—

	Per cent
Methane	67
Ethane	0.04
Propane	0.01
Butane	0.01
Pentane and higher . .	0.07

Other bacteria have been investigated which are capable of producing hydrocarbons from fatty acids. The first type to be studied was a sulphate-reducing bacteria which when grown in sea water enriched with fatty acids, at a temperature of 78°F, produced appreciable amounts of oil-like ether-soluble, non-saponifiable matter. From *n*-caproic acid, extracts, tentatively identified as a mixture of *n*-paraffins from $C_{15}H_{32}$ to $C_{25}H_{52}$, and wax were obtained. Other fatty acids gave similar results. Other bacteria have since been discovered which are capable of decomposing, or fermenting, organic matter with the production of hydrocarbons and hydrogen. The activity of these bacteria is controlled by the Redox potential and *p*H of the marine sludge and maximum production of hydrogen is obtained within very narrow limits of both criteria.

Zobell's "Marine Microbiology" surveys the field of these researches and has done much to strengthen the view that petroleum has been formed by bacterial action within sediments containing organic matter, and that the conditions of sedimentation (*p*H of the water, Redox potential, salinity, etc.) may well have exerted a marked influence on the course of the bacterial decomposition.

The view that much of the organic matter from which petroleum has been formed may have been bacterial protoplasm has been advanced with the suggestion that the methane produced by anaerobic decomposition might interact with the partially reduced organic matter and so lead to the formation of petroleum. There is, however, little experimental evidence in support of these views.

The relationships between crude oil composition and stratigraphy have been intensively studied in two main areas. The pioneer work of D. C. Barton in the Gulf Coast area and the extensive surveys of Krecji Graf and Hlauschek in Europe were based on certain physical properties of the various fractions of the crude oils. Hlauschek's "depth rule" and "age rule" for instance relate to bulk properties of the crude oils, and differences in, for instance, specific gravity of crude oils with depth may not necessarily be results of the change in type of crude oil, but may be due to changes in the relative amounts of light fractions in the crude, caused possibly by physical effects in the reservoir rather than by differences in the origin of the oil. Obviously a much more detailed

analysis of the crude oils is necessary in order to establish differences in the chemical nature of oils independent of physical characteristics.

The Research Committee of the Tulsa Geological Society have accordingly undertaken an extensive survey of the crude oils of Northeast Oklahoma and Southwest Kansas. Oils were analysed by the U.S. Bureau of Mines Hempel distillation method, and characterized by their correlation index curves. Several hundred samples of crude oils were examined ranging from the upper part of the Arbuckle limestone of Ordovician age to sands of Pennsylvanian age. The oils from pools associated with the unconformity at the top of the Arbuckle limestone and at the top of the Mississippi lime were extremely variable, but the oils from the Burbank sand, distributed through an area 150 miles long and 1 to 35 miles wide were all of one class. This sand is an old shore line and is confined to a very narrow stratigraphical horizon; the lithology is similar throughout. The similarity of oils within this sand shows that the depth of burial and degree of folding (which is severe in some areas) have had no effect upon the character of the oil and the authors suggest that the controlling factor in the character of the oil has been the original environmental conditions of deposition of the source rock. This would be similar or identical for the Burbank sands but would vary considerably in rocks connected with an extensive unconformity. In the case of lenticular sands associated with the unconformities it is suggested that the oil has originated within the sand, or within the immediately surrounding clay bodies.

The degree of fractionation involved in the U.S. Bureau of Mines Hempel distillation is not very high and for this reason the use of the correlation index alone for distinguishing between different oils is not entirely satisfactory. The Tulsa Geological Research Committee have, however, included in the analytical details the sulphur content and other properties of the crude oils. This enables a degree of comparison to be made with the many thousands of analyses by this method published by the U.S. Bureau of Mines. There can be little doubt that the oils throughout the entire Burbank sand are so similar in character that the conclusion that the sand contains only one type of oil is justified.

Comparison of the oils in the lenticular sandstones above the unconformities is however less simple, but again the view of the authors that the variety of oils found is indicative of different source environment or material is supported by the analysis. There does not appear to be any relationship between the distribution of oil types and structural features such as might be expected had the oils originated in a common source rock removed from the immediate vicinity. This is however not entirely proved by the published details.

An intensive survey of the Miocene oils of south-west Trinidad has been undertaken by the Research Division of Trinidad Leaseholds Ltd., with the object of supplying evidence concerning the origin of these oils. The method of analysis used enabled a detailed estimate to be made of the individual hydrocarbon components in the gasoline fraction, and certain properties of the residues, such as asphaltene, sulphur, and nitrogen content permitted correlations in the basis of the crude oil. Three distinct areas have been examined and reported, the crude oils of the Forest Sands of the Bernstein field, the oils of the Forest, Upper and Middle Cruse sands of Morne Diablo-Quinan and the oils of the Forest, Middle and Lower Cruse sands of the Forest Reserve field.

The wells in these areas produce from a number of sands, and since the sands are in many cases lenticular the problem of correlation has proved extremely difficult. In the Morne Diablo-Quinan

field, where the Middle Cruse sands are continuous and approximate to sheet sands, examination of the analysis of various groups of oils produced from one, two, three, four, or five sands permitted the assignment of a discrete oil type to each sand. In the Bernstein field, examination of the oils of the Forest sands indicated a movement of oil through the field and this was illustrated by contour maps of various chemical parameters on the geological map of the field. A particular movement of oil was observed, apparently originating along one side of a major fault and spreading into the four Forest sands.

Subsequent investigation showed the distribution of oil types to have evened out, suggesting that the migration observed was a temporary, production induced, migration. The complete investigation of the oils of the Forest Reserve field—Forest sands, Upper-Middle, and Lower Cruse sands occupied a period of four years and involved the analysis of over 1000 individual crude oils. Obviously the publication of these analytical data in a complete form in a journal was impossible, but a summary of the results* was presented to the World Petroleum Congress, The Hague, 1951. This shows that each individual sand of the many sand zones examined contained a discrete oil, the type of oil varying slightly from naphthenic oils in the Forest and Upper Cruse sands, to a naphthene-paraffinic type in the Middle Cruse sands and to naphthenic oils in the Lower Cruse sand.

No regional variation related to tectonic features could be observed. The older theories that the oils of the Miocene sands had migrated from some deeper source rock, the migration proceeding via the Los Bajos fault and other faults, could not be supported and it was suggested that the oils had been formed in the underlying clays and marls which, having extensive development into the synclinal basin, could have contained sufficient organic matter to serve as source material. The evidence obtained in the Morne Diablo-Quinan field supported this view. The minor variations in oil type observed were believed to be due to changes in source material and depositional environment throughout the Miocene period.

It is significant that both the Tulsa Geological Society survey and the Trinidad Leaseholds surveys—the only surveys on such extensive and intensive bases which have yet been made on any multizonal petroliferous province, should state that the evidence in each case indicated an indigenous origin of the variety of oils in each area. In both cases the possibility of migration from a deeper source rock had been postulated by earlier workers, but in each case the regional variation in oil types precluded the acceptance of any such migration. It may well be that other investigations in other areas will establish beyond doubt vertical migration from depth, and it is obviously desirable that all areas in which, on geological grounds, migration over some distance is a possibility should be submitted to exhaustive analysis. In the meanwhile the evidence of these surveys supports the view that oil is formed by shallow depth of burial and moves to the adjacent reservoir rocks shortly thereafter—and that variations in oil type are due to variations in source material and environment.

The exact mechanism by which the source material is converted to petroleum is however still in doubt. Treibs has suggested a sequence of events, first a micro-biological process, anaerobic in character, to convert fats, proteins, cellulose, sterols, etc., into a "protopetroleum" of indeterminate character, followed by catalytic processes involving rearrangement, isomerization, polymerization, cracking, and cyclization.

Proc. Third World Petrol Congr., 1951, 1, 345-55.

By what catalysts these are brought about is not certain, but Treibs suggests, as does Brooks, that clay minerals, particularly Bentonites, Montmorrillonite, etc., are very active catalysts and that in the finely divided state with which they would be associated with the organic matter in the early sediments they would be even more active. Following earlier work of Lind on the action of α-radiation on organic matter, Sheppard and his colleagues have investigated the dehydrogenation and decarboxylation of fatty acids on bombardment with α-particles as part of the API research project No. 43C. The investigation of the organic content and radioactivity of a large number of sedimentary rocks by Russell has shown a marked relationship between certain types of organic matter and radioactivity. The significance of these results in relation to the genesis of petroleum is still under discussion. The most satisfactory approach to the problem would appear to lie in the work of Zobell. An intensive search for micro-organisms capable of converting the variety of source materials suggested by Treibs into hydrocarbons, or the intermediates postulated, is now necessary. Further studies of the relationship between crude oil composition and stratigraphy throughout oilfields of the world is also much to be desired. In the present state of knowledge one fact is worth more than a multitude of theories.

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NEW IP PUBLICATIONS

New publications of considerable interest to the petroleum industry which have recently been issued by the Institute are:

Mass Spectrometry. In April 1950 the Mass Spectrometry Panel organized a conference on the subject and this was held in Manchester over a period of two days. In all fourteen papers on four main aspects of mass spectrometry were presented—(*a*) Ionization and dissociation of molecules; (*b*) Instrumental aspects; (*c*) Applications; (*d*) Preparation of standard gases. The report contains 205 pages and includes not only the papers and the discussion but also a comprehensive bibliography of nearly 700 references and brief notes for the years 1938-50. Price is 30s. post free (25s. to IP members).

Standard Methods. The 12th edition of "Standard Methods for Testing Petroleum and Its Products" includes details of 121 methods for the testing of petroleum. Two new methods, oxidation stability of aviation gasoline, and soluble cutting oil—oil content of dispersions, are included and, in order to achieve uniformity in the form of methods, sixty-eight of the existing methods have been revised editorially. In over twenty methods technical revisions have been made and the range of analytical solvents for which specifications are given has been widened. Where applicable IP standard thermometers may be graduated in either Fahrenheit or Celsius scales. Price is 40s. post free (35s. to IP members).

Petroleum Measurement Manual. During the past four years, the Measurement and Sampling Sub-Committee has devoted much time and thought to the methods by which accurate measurement of bulk quantities of liquid petroleum products can be achieved. The result of their work is now available in this book of 227 pages which, in its six parts lays down instructions and details of apparatus for tank calibration, oil gauging, sampling for quantitative purposes, temperature measurement, specific gravity and density measurement, and calculation of oil quantities. The committee is confident that the adoption throughout the industry of

their recommended procedures will result in close agreement nationally and internationally in calculated quantities. Price is 30s. (25s. to IP members).

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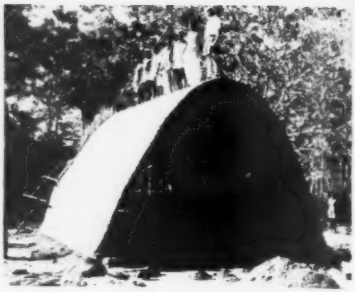

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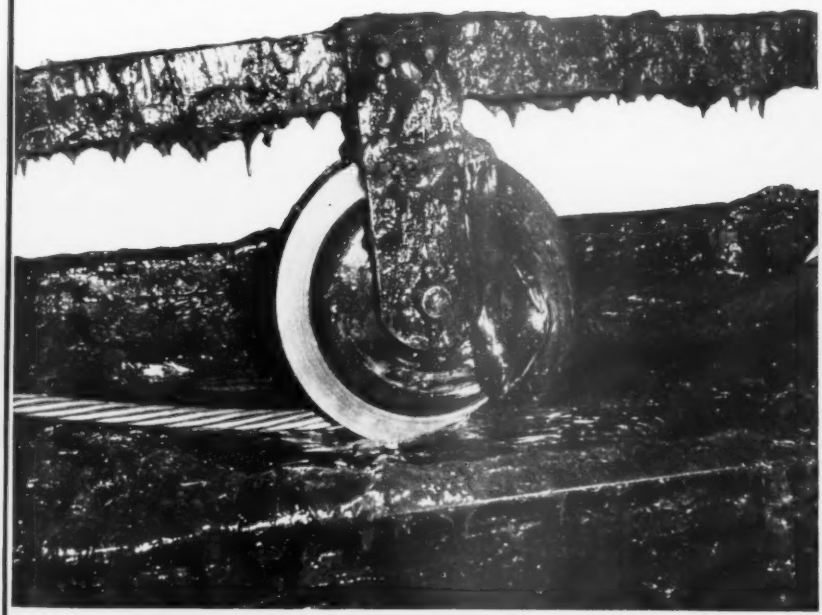

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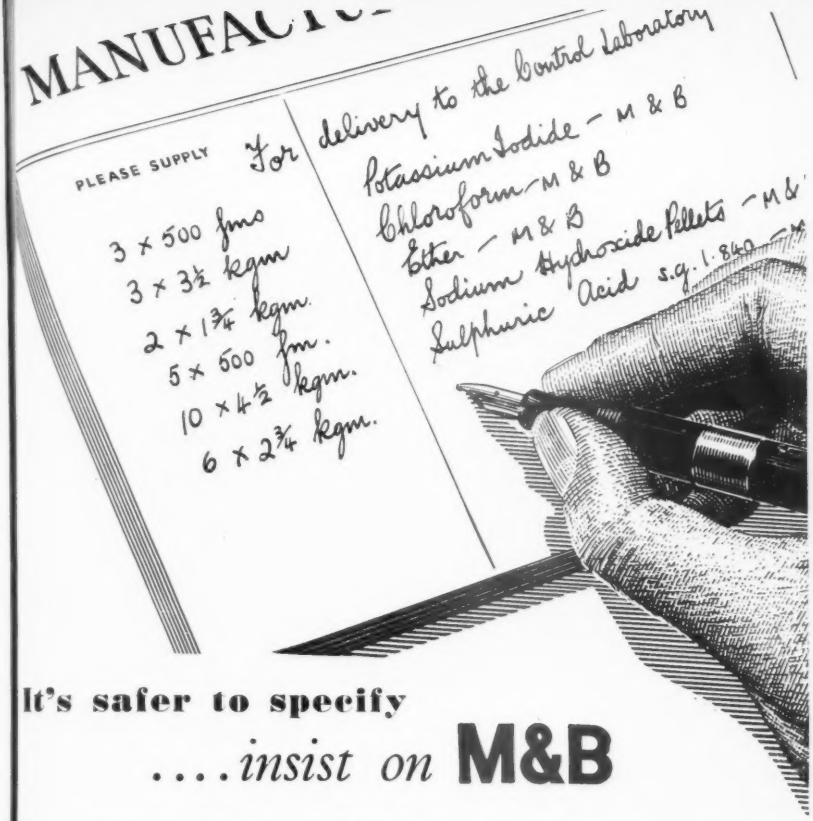
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